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BEFORE THE BOARD OF PATENT APPEALS AND INTERFERENCES

Application Number: 09/755,071
Filing Date: January 08, 2001
Appellants: AHN ET AL.

Thomas J. D'Amico
For Appellants

EXAMINER'S ANSWER

This is in response to the appeal brief filed January 3, 2005.

(1) Real Party in Interest

A statement identifying the real party in interest is contained in the brief.

(2) Related Appeals and Interferences

A statement identifying the related appeals and interferences that will directly affect or be directly affected by or have a bearing on the decision in the pending appeal is in the brief.

(3) Status of Claims

The statement of the status of the claims contained in the brief is correct.

(4) Status of Amendments

The Appellants' statement of the status of amendments after final rejection contained in the brief is correct.

(5) Summary of Claimed Subject Matter

The summary of the claimed subject matter contained in the brief is correct.

(6) Grounds of Rejection to be Reviewed on Appeal

The Appellants' statement of the grounds of rejection in the brief is correct.

(7) Claims Appealed

The copy of the appealed claims contained in the Appendix to the brief is correct.

(8) Prior Art of Record

6,362,528	Anand	3-2002
6,093,966	Venkatraman et al.	7-2000

Min et al., "Metal-Organic Atomic-Layer Deposition of Titanium-Silicon-Nitride Films," Applied Physics Letters, Vol. 75, No. 11, Sept. 13, 1999, pp. 1521-23.

Reid et al., "Ti-Si-N Diffusion Barriers Between Silicon and Copper," IEEE Electron Device Letters, Vol. 15, No. 8, Aug. 1994, pp. 298-300.

(9) Grounds of Rejection

The following grounds of rejection are applicable to the appealed claims:

The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

> (a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made.

Claims 19, 21, 22, 24, 25, 28 and 30 are rejected under 35 U.S.C. 103(a) as being unpatentable over Anand in view of Min et al. Anand teaches, with reference to figures 8-19, a dual damascene structure comprising:

a semiconductor substrate 11;

a first insulating layer 25 provided over the substrate;

a metal layer 17b provided within the first insulating layer;

at least another or second insulating layer 18 provided over the metal layer;

a via 19a situated within the second insulating layer 18 and extending to at least a portion of the metal layer, the via being lined with a titanium-silicon-nitride layer 20a and filled with a copper material 20b (col. 13, lines 11-13 and lines 17-18);

a third insulating layer 27 located over the second insulating layer;

a trench 19b situated within the third insulating layer and extending to the via, the trench being lined with the titanium-silicon-nitride and filled with copper (col. 13, lines 11-13, 17-18).

Anand does not expressly teach that the Ti-Si-N layer has a step coverage of about 100%. However, Min et al. teach a Ti-Si-N layer which achieves about 100% step coverage. *Abstract*, last sentence. Anand and Min et al. are combinable as they are from the same field of endeavor

as applicant's invention. At the time of the invention, it would have been obvious to a person of ordinary skill in the art to form the Ti-Si-N layer of Anand using the deposition process taught by Min et al. so that the Ti-Si-N layer had step coverage of about 100%. The motivation for doing so, as is known in the art, is that near perfect step coverage ensures that no thin spots are formed on the sidewalls of trenches and vias and thus ensures copper does not diffuse into the surrounding silicon. Moreover, Min et al. teach that the Ti-Si-N layer formed having near 100% step coverage prevents copper diffusion up to 800°C for 60 minutes and such deposition process can precisely control the thickness and composition of the grown film. (Min et al., second paragraph). As such, it is considered obvious to combine Anand and Min et al. to achieve the device of claims 19, 21, 22, 24, 25, 28 and 30.

Regarding the limitation that the titanium-silicon-nitride layer which lines the via is formed by an organo-metallic-atomic deposition process, such limitation does not further define the structure as instantly claimed, nor serve to distinguish over Anand. Note that a "product by process" claim is directed to the product per se, no matter how actually made, In re Hirao, 190 USPQ 15 at 17 (footnote 3). See also In re Brown, 173 USPQ 685; In re Luck, 177 USPQ 523; In re Fessmann, 180 USPQ 324; In re Avery, 186 USPQ 161; In re Marosi et al., 218 USPQ 289; and particularly In re Thorpe, 227 USPQ 964, all of which make it clear that it is the patentability of the final product per se which must be determined in a "product by process" claim, and not the patentability of the process, and that an old or obvious product produced by a new method is not patentable as a product, whether claimed in "product by process" claims or not. Note that applicant has the burden of proof in such cases, as the above case law makes clear.

Alternatively, it is noted that the process taught by Min et al. is the same organo-metallic-atomic deposition process that is used to form the Ti-Si-N layer of the instant claims. Therefore, if such a process does result in a structural difference as compared with the method employed by Anand, such structure will necessarily result from the combination of Anand and Min et al. Furthermore, as discussed above, Min et al. motivate the use of their process in that it provides near 100% step coverage, prevents copper diffusion at high temperature and precisely controls the thickness and composition of the deposited film. As such, even assuming a Ti-Si-N layer formed by an organo-metallic-atomic deposition process will result in a layer structurally different from that of Anand, such a layer is taught and made obvious by Min et al.

With regard to claims 21 and 22, Anand teaches that the another or second insulating layer 18 is formed of silicon dioxide and is 1 μm or 10,000Å thick (col. 12, lines 35-37). With regard to claims 24 and 25, Anand teaches that the third insulating layer 27 is formed of silicon dioxide and is 6,000 Å thick (col. 11, lines 41-42, lines 48-50, see also col. 11, lines 52-54). With regard to claim 28, Anand teaches that the copper material is copper (col. 13, lines 17-18). With regard to claim 30, Anand teaches that the substrate is silicon (col. 11, line 32).

Claims 20, 23 and 40-42 are rejected under 35 U.S.C. 103(a) as being unpatentable over Anand and Min et al. and further in view of Venkatraman et al. Anand and Min et al. make obvious the structure of independent claim 19 as well as independent claims 40 and 42. Anand also teaches the use of an etch stop layer 24 or 26 used between insulation layers. However, they do not teach that the insulating layers may be formed of polyimide. Venkatraman et al. teach that an insulating layer may be formed of silicon dioxide or polyimide (col. 4, lines 39-54). With

regard to claim 40, Anand teaches that the integrated circuit which includes the dual damascene structure is formed as part of a ULSI circuit which is considered a processor. Anand also teaches that the integrated circuit having the damascene layers is formed on the same chip as the processor (see generally figures 21-24).

Anand, Min et al. and Venkatraman et al. are combinable because they are from the same field of endeavor. At the time of the invention it would have been obvious to a person of ordinary skill in the art to use polyimide as the insulator of Anand. The motivation for doing so is that such a material has a low dielectric constant such that parasitic capacitance between conductors is reduced. Therefore, it would have been obvious to combine Anand and Min et al. with Venkatraman et al. to obtain the device of claims 20, 23 and 40-42.

Claims 26 and 27 are rejected under 35 U.S.C. 103(a) as being unpatentable over Anand and Min et al. and further in view of Reid et al. Anand and Min et al. make obvious the device of claim 19. However, they did not teach that the TI-Si-N liner layer is between 50-200 Å thick or specifically 100 Å thick. Reid et al. teach, on page 229 in the right hand column, first full paragraph, that a layer of Ti-Si-N may be formed at a thickness of 10 nm (100Å).

Anand, Min et al. and Reid et al. are combinable because they are from the same field of endeavor. At the time of the invention, it would have been obvious to a person of ordinary skill in the art to form the Ti-Si-N layer to a thickness of 100Å. The motivation for doing so, as is taught by Reid et al., is that such thickness is sufficient to prevent copper migration up to a temperature of 650° C. Therefore, it would have been obvious to combine Reid et al. with Anand and Min et al. to obtain the invention of claims 26 and 27. It is also noted in this

Examiner's answer that Min et al. do in fact teach formation of the Ti-Si-N layer to a thickness of 10 nm (=100Å). See Min et al. at the description of figure 3, second to last line.

Claims 31, 33, 34, 37 and 39 are rejected under 35 U.S.C. 103(a) as being unpatentable over Anand in view of Venkatraman et al. and Reid et al. As discussed in the above rejections, Anand teaches the structure of instant claim 31 but does not teach a polyimide insulator or a Ti-Si-N layer with a thickness of about 100 Å. Venkatraman et al. make obvious the use of polyimide and Reid et al. makes obvious the thickness of 100 Å. As such, the instant claims are rejected there under.

(10) Response to Argument

I. Summary of the Rejection

As stated in Appellants' brief on page 4, the instant invention is drawn to a damascene structure having a via lined with a titanium-silicon-nitride (Ti-Si-N) layer and filled with copper. The appealed claims also cite that the Ti-Si-N layer is formed by an "organo-metallic atomic deposition method." *Brief*, p. 5. The prior art reference Anand anticipates the instant claims but for the specific *method* of forming the Ti-Si-N layer, which method achieves a near 100% step coverage of the layer. Specifically, Anand teaches in figure 19 a dual damascene structure including a trench 19b lined with Ti-Si-N 20a and filled with copper 20b. Note that while Anand does show in figure 19 the Ti-Si-N layer having 100% step coverage, as seen by the constant thickness of the layer on the sidewall of the trench and via, Anand does not expressly state such limitation. Because Anand does not teach that its Ti-Si-N layer is deposited by an organo-metallic-atomic deposition *process*, nor expressly state that the layer has a near 100% step coverage, Min et al. was cited for that specific teaching. As made clear in its title, Min et al.

teach forming a Ti-Si-N layer by an organo-metallic-atomic deposition process and specifically teach that such process achieves a near 100% step coverage.

The rejection is proper and satisfies the three-tier requirement for obviousness. Anand and Min et al. are analogous art - the art of semiconductor fabrication; note the title of Anand, and the first sentence of Min et al. Min et al. provide motivation for using their process when forming a Ti-Si-N layer such as that of Anand – that such formation prevents copper diffusion at high temperatures, provides 100% step coverage even in holes having high aspect ratios and allows precise control of the thickness and composition of the film. In combination, the prior art references teach all the claimed limitations, Min et al. provide explicit motivation to use their method in the structure of Anand, and there is certainly a reasonable expectation of success as Min et al. provide explicit instructions for performing their method and there is no evidence to refute such expectation. In all, the court's three-tier requirement for a *prima facie* obviousness rejection is met (*In re Dembiczak*, 175 F. 3d 994 (Fed. Cir. 1999)), the obviousness rejection is proper and the rejection should be affirmed.

II. The Obviousness Rejection Over Anand in View of Min et al.

A. The Limitation "organo-metallic-atomic deposited titanium-silicon-nitride layer" *is* a Product-by-Process Limitation.

Appellants have argued throughout this prosecution and again argue here that the limitation "an organo-metallic-atomic deposited titanium-silicon-nitride layer" is not a product-by-process limitation but is rather a *resulting structure*. *Brief*, p. 11, emphasis in original. To support that conclusion, Appellants quote from the instant specification which states, "Ti-Si-N films **deposited** by an organo-metallic-atomic layer deposition (ALD) **method** ..." and again quotes, "the Ti-Si-N films **formed** by the above described ALD **technique**...". *Brief*, p. 12,

emphasis added. It is not clear, especially from these quotations, how the claimed Ti-Si-N layer, which is *deposited* by an organo-metallic-atomic *method*, is anything *but* a product formed by a particular process. Indeed, Appellants argue that Anand fails as a reference since the instant claim is drawn to an "*organo-metallic-atomic deposited titanium-silicon-nitride layer*" *id.*, emphasis in original, whereas Anand teaches a titanium-silicon-nitride layer "formed ... *by the CVD method or PVD method*" *id.*, emphasis in original. These arguments support the conclusion that the limitation *is* a product formed by a particular process.

Appellants also cite several cases for support (*R2 Medical Systems, Inc. v. Katecho, Inc.*, 931 F.Supp. 1397 (N.D. Ill. 1996), *In re Garnero*, 412 F.2d 276 (CCPA 1969) and *Hazani v. U.S. Int'l Trade Comm'n*, 126 F.3d 1473 (Fed. Cir. 1997)) to conclude that "the limitation 'organo-metallic-atomic deposited titanium-silicon-nitride layer' **is not a product formed by a particular process**." *Brief*, p. 12, emphasis added. However, these cases do not support Appellants' position. As quoted by Appellants, in *R2 Medical Systems* the court found that "the terms of the claims do not indicate that 'affixed' refers to a process by which the stannous chloride is bound to the conductive plate, but only that it refers to the result of that process." However, the term "affixed" must be considered a generic term, much like the term "deposited" is generic. But Appellants' claims are not limited to the generic term "deposited" and instead cite a species of deposition – organo-metallic-atomic *deposited* Ti-Si-N. As Appellants have argued, this deposition is different from Anand's method which uses a chemical vapor *deposition* (CVD) or plasma vapor *deposition* (PVD) method. As such, the generic term *deposition*, like affixed, may not connote a processing limitation, but the more specific organo-metallic-atomic deposition certainly does.

In *Hazani*, the court held that a memory cell comprising a conductive plate having a surface that was "chemically engraved" was a pure product claim. To support their conclusion, the court read the limitation in context and determined that it described the product more by its structure rather than by the process used to obtain it. However, it is not clear how the limitation "organo-metallic-atomic deposited" could be considered more descriptive of the final structure as opposed to describing the *process* used to obtain the final structure. Perhaps like the term "affixed," the term "deposited" could be seen to describe the final structure, but certainly the phrase "organo-metallic-atomic deposited" is drawn to the process.

Finally, the court's holding in *Garnero* no more supports Appellants' position than does *R2* or *Hazani*. In *Garnero*, the court held that the limitation "interbonded ... by interfusion" should be treated as a structural rather than a process limitation. Aside from another example of the court's interpretation of certain claim limitations, it is not clear how the interpretation of "interbonded ... by interfusion" relates to organo-metallic-atomic deposited. What can be gleaned from this case is how product-by-process limitations should be treated; The structure implied by the process steps should be considered when assessing the patentability of the product-by-process claims over the prior art, especially where ... the manufacturing process steps would be expected to impart distinctive structural characteristics to the final product. 412 F.2d at 279. See also MPEP §2113. Thus *Garnero* does not mandate the treatment of all processing limitations as structural limitations, but rather does mandate the consideration of processing limitations for all they imply to the resulting structure. As will be seen in the following section, such consideration was performed. In all, the limitation "organo-metallic-atomic deposited" is a product-by-process limitation and the arguments are not persuasive.

B. The Product-by-Process Limitation "organo-metallic-atomic deposited titanium-silicon-nitride layer" was Properly Considered for the Structure It Implies to the Final Product but any Structural Difference is Obvious Since the Claimed Process is Obvious.

As discussed above, the phrase "organo-metallic-atomic deposited titanium-silicon-nitride layer" is considered a product-by-process limitation - it is a titanium-silicon-nitride layer deposited by an organo-metallic-atomic deposition process. Still, the processing limitation was considered for all it implied to the claim's final structure, especially in light of applicant's amendment dated December 10, 2003, which added the purported resultant structural difference to the claim (that the Ti-Si-N layer has step coverage of near 100%). As argued by Appellants, an organo-metallic-atomic deposition results in the structural difference of "near-perfect step coverage" *brief*, p. 13 or "step coverage of about 100%." Claim 19. Though it is not clear that the claimed process does result in a structure unique over Anand, the issue is essentially moot as Min et al. motivate formation of the Ti-Si-N layer by an organo-metallic-atomic deposition process so that any structural differences would necessarily result and are also made obvious.

First, it is not clear that the CVD or PVD process of Anand does not achieve the claimed step coverage. Anand shows in figure 19 near perfect step coverage and Appellants have offered no evidence to the contrary. Indeed, Appellants can do no more than assert that "a person skilled in the art would conclude that the properties of the Ti-Si-N film associated with the metal-organic-atomic deposition of the present invention are different from the properties of a Ti-Si-N film formed by chemical vapor deposition." *Brief, p. 13.* However, despite this lack of evidence, the rejection assumed that the asserted structural difference would manifest itself and result in a structure unique from Anand. But, such structural difference is made obvious by Min et al. since Min et al. teach and motivate the formation of Ti-Si-N by an organo-metallic-atomic deposition

process. Specifically, and as was made clear in the rejection, Min et al. teach that formation of Ti-Si-N by organo-metallic-atomic deposition results in "step coverage of about 100%", prevents copper diffusion and allows precise control of the resultant film's thickness and composition (Min et al., *Abstract*, last 2 sentences and 2nd paragraph). Certainly Appellants must agree with Min et al.'s teaching as they cite to the same and even provide additional motivation for its use. *Brief*, p. 12. In all, even assuming a structural difference is achieved by the claimed deposition process, such process and thus structure is taught in the art by Min et al. and motivated for use with Anand. As such, arguments that the processing limitation was not properly treated are unpersuasive.

C. Anand and Min et al. are Analogous Art and Motivation Exists for Their Combination.

Appellants argue that the combination of Anand and Min et al. must fail as there is no suggestion or motivation for their combination, that there is no teaching, suggestion or incentive to make the combination made by the inventor. *Brief*, p. 14, citing *Northern Telecom v. Datapoint Corp.*, 908 F. 2d 931 (Fed. Cir. 1990) as well as other cases supporting the same requirement. Appellants specifically allege that the final rejection fails because Anand is drawn to forming a lattice-like bond pad while Min et al. is drawn to a specific process for depositing Ti-Si-N and that the only thing in common between the two references is the substrate on which their devices are formed. *Brief*, pp. 14-15. This argument is not persuasive.

As stated by Appellants, and here the Examiner concurs, Anand does teach the formation of a lattice-like bond pad. This is clearly seen in figures 18 and 19 of Anand where the bond pad structure is shown on the left-hand side of both figures. However, those same figures show on the right-hand side the instantly claimed metallization or damascene structure. Such damascene

structure cannot be ignored simply because it is used in conjunction with a bond pad structure. Appellants attempt to further undermine the teaching of Anand in that Anand only discusses the damascene processing and structure as background. *Brief*, p. 15. However, this does not undermine Anand's combination with Min et al. but only shows that such damascene structures were well known. Indeed, there is nothing structurally different between the instant claims and the teaching of Anand aside from the process (and perhaps resultant structure) by which the Ti-Si-N layer is formed. But, as made clear in the rejection, Min et al. teach such Ti-Si-N formation and provide motivation for using that process. Again, Min et al. teach that a Ti-Si-N layer formed by an organo-metallic-atomic deposition process provides step coverage of about 100% and prevents diffusion of copper up to 800°C for 60 minutes. Despite Appellants' arguments to the contrary, it is not clear how Anand and Min et al. cannot be combined. Anand and Min et al. teach all the claimed limitations, they are analogous art as both are drawn to semiconductor fabrication and specifically to the formation of metallization structures and motivation is supplied by the references for their combination. In all, the rejection has established a *prima facie* case of obviousness which has not been rebutted and should be upheld.

III. Rejections of the Remaining Claims in View of Venkatraman et al. and/or Reid et al. Properly Establish *Prima Facie* Cases of Obviousness and Should be Upheld.

Appellants argue that the rejection of claims 20, 23 and 40-42 would not have been obvious over Anand and Min et al. in view of Venkatraman et al., that claims 26 and 27 would not have been obvious over Anand and Min et al. in view of Reid et al., and that claims 31, 33, 34, 37 and 39 would not have been obvious over Anand in view of Venkatraman et al. and Reid et al.

Regarding claims 20, 23 and 40-42, Appellants assert that the rejection is flawed because none of the references, including Venkatraman et al., disclose an organo-metallic-atomic deposited titanium-silicon-nitride layer. *Brief*, p. 18. This is not persuasive because, as pointed out above, Min et al. do teach and motivate the formation of such a Ti-Si-N layer by an organo-metallic-atomic deposition process. Appellants also argue that none of the references teach an etch stop layer or an insulating layer formed of polyimide. However, as pointed out in the final rejection, Anand teaches an etch stop layer. Furthermore, contrary to Appellants' assertion, Venkatraman et al. do teach a polyimide layer in column 4, lines 39-54 and motivate its use as it is a low-K dielectric. Appellants also argue that Venkatraman et al. was improperly combined with Anand and Min et al. as it is drawn to formation of a copper barrier layer. However, this better supports the argument that Venkatraman et al. *is* analogous art to Anand and Min et al. as they are all concerned with copper barriers. Specifically, Anand teaches a Ti-Si-N barrier layer, Min et al. teach a Ti-Si-N barrier layer and as pointed out by Appellants Venkatraman et al. teach formation of a Ti-Si-N barrier layer (*Brief*, pl. 18). Furthermore, Venkatraman et al. provide motivation for its use as it provides a low-K dielectric. In all, the combination of Anand and Min et al. with Venkatraman et al. is proper and arguments to the contrary are not persuasive.

Appellants similarly argue that Reid et al. fail to overcome the deficiencies of Anand and Min et al., as Reid et al. do not teach an organo-metallic-atomic deposited titanium-silicon-nitride layer but instead use a different process. However, as discussed above, Min et al. already teach and motivate the layer made by the claimed process so the argument is not persuasive. Moreover, Reid et al.'s disclosure does not teach away from Min et al.'s process but is merely an

alternative, and no evidence to contrary has been provided. Reid et al. was relied on for teaching the claimed specific thickness of the Ti-Si-N layer. Reid et al. do teach such a specific thickness and provide motivation for its combination. Indeed, Appellants point out as much by quoting Reid et al., "Reid teaches that '$Ti_{34}Si_{23}N_{43}$ thin films are exceptional diffusion barriers between silicon and copper' and that '100nm and 10nm films are able to prevent copper from reaching the silicon'" *Brief*, p. 21, quoting Reid et al., p. 299, 2nd column, last paragraph. It is also noted that subsequent review of Min et al. shows that Min et al. describes in figure 3 the formation of a 10nm Ti-Si-N layer. Finally, Appellants also assert that Reid et al. is not analogous art in that it is drawn to formation of Ti-Si-N layers as diffusion barriers between copper and silicon. *Brief*, p. 21. However, this is exactly the nature of Anand and Min et al. As analogous art, Reid et al. teach the claimed thickness and provide motivation for its use, the rejection is proper and arguments to the contrary are not persuasive.

Lastly, Appellants argue that claims 31, 33, 34, 37 and 39 are patentable over Anand in view of Venkatraman et al. and Reid et al. Appellants assert that none of the references teach the claimed insulating layer material or the claimed opening lined with a Ti-Si-N layer having thickness of about 100Å. However, as pointed out in the above arguments, the references in combination do teach and make obvious all recited claim elements. Appellants also argue that motivation is lacking for combining the references. However, again as pointed out above, all references are concerned with the formation of metallization layers filled with copper and the prevention of copper diffusion into silicon. As such, the rejection is proper and arguments to the contrary are not persuasive.

IV. Conclusion

The invention is drawn to a damascene structure having a Ti-Si-N barrier layer which lines vias and trenches, the Ti-Si-N layer formed by a specific process. Anand teaches the structure including the Ti-Si-N layer but does not teach that the layer was formed by the claimed process. Though it is not evidenced that a structural difference results from the claimed process, Min et al. teach and motivate formation of a Ti-Si-N layer by the process so that any arguments thereto are silenced. Together, Anand and Min et al. teach all elements of the claimed invention, provide motivation for their combination and thus the rejection is proper. The additional references used to reject the remaining claims are analogous art and provide motivation for their use. In all, the final rejection was proper and arguments to the contrary are not persuasive.

For the above reasons, it is believed that the rejections should be sustained.

Respectfully submitted,

GEORGE ECKERT
PRIMARY EXAMINER

April 1, 2005
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